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WATERSHED MANAGEMENT OF CHINCHOLI VILLAGE BY GIS

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ABSTRACT

A watershed is a land surface area bounded by a divide that channels runoff to a common point. Effective watershed management involves the strategic conservation and utilization of land, vegetation, and water resources to maximize water retention, reduce soil erosion, and ensure sustainable agricultural productivity. It plays a crucial role in maintaining a stable and clean water supply while mitigating the risks of uncontrolled runoff and flooding.

The study utilizes ArcGIS Pro for geospatial analysis and mapping. Key maps prepared include contour maps, drainage maps, land use land cover (LULC) maps, groundwater level maps, rainfall distribution maps, and soil maps. These maps assist in understanding watershed characteristics, soil composition, and hydrological behavior. The primary data sources include Bhuvan, USGS Earth Explorer, India-WRIS, Esri datasets, and rainfall data from IMD Pune. Additionally, runoff calculations are performed to assess water availability and surface water flow. Based on topographical and hydrological analyses, watershed structures are proposed, followed by design and cost estimation to improve water conservation and resource management in Chincholi village.

This study highlights the role of GIS-based watershed modeling in sustainable water resource management and demonstrates how advanced spatial analysis techniques and runoff modeling can enhance watershed planning and implementation.

KEYWORDS: Watershed Management, GIS, ArcGIS Pro, Digital Elevation Model, Remote Sensing.

1. INTRODUCTION

A watershed is a geo-hydrological area where all precipitation and runoff drain to a common outlet, such as a stream, river, or lake.[1] It plays a vital role in managing rainfall and surface runoff, particularly in hilly and rain-fed regions. However, watersheds often face degradation due to unregulated land use, deforestation, mining, construction, and soil erosion. [2] The Himalayan region, one of the world's most critical watersheds, is especially vulnerable to such impacts. [3] India began implementing watershed development initiatives as early as 1949 with the Damodar Valley Corporation. [4] Over time, emphasis shifted towards micro-watershed development, especially in drought-prone areas, supported by various national policies and expert committees. [5]

With advancements in technology, Geographic Information Systems (GIS) have become essential in watershed analysis. ArcGIS Pro, developed by Esri, is a robust GIS platform used for spatial data visualization, analysis, and modeling. [6] In this study, ArcGIS Pro is employed to create contour, drainage, land use/land cover, groundwater, rainfall, and soil maps. [7] Runoff calculations are also carried out using data from sources like Bhuvan, USGS Earth Explorer, India-WRIS, and IMD Pune. [8] This approach allows for comprehensive environmental and hydrological assessments to support effective watershed management. [9]

Watershed management is a coordinating framework for environmental management; watershed management is about using of soil, water and vegetation in a way that not only conserves the natural resources but also maximizes the productivity of the lands by focusing on the hydrological linkage between the shared and individually-organized areas. [10] Since a watershed is part of the land that is used for agriculture, manufacturing, and other human acttv1ttes, watershed management is important not only from an economic point of view because of optimizing environmental services for human uses but also from a political perspective because of simplifying resource management for policymakers. [11]

Bhavana Umrikar [1] (2015) studied The Shringar Tali watershed, a representative of NNW-SSE running stream originating on lateritic plateau, has been selected to suggest a model for watershed development. Upendra R. Saharkar [2] (2016) in this paper, Author done watershed is using remote sensing and GIS software for Talegaon dabhade, pune district. In this study population and industrial area is increasing day by day so that ground water level is depleting by 0.2m per year

and soil erosion also increased. Omkar Prakash Suryawanshi et al. [3] (2015) studied water resource management in their paper Water Resources Management for Sustainable Development of Sadale-Madale Village, Kolhapur. In this study they have shown that, for the effective water resource management Efforts are made to manage the resources by some economic as well as technical watershed management. Sharada S. Tanavade et al. [4] (2015). A Case Study of Watershed Development in Sangola Maharashtra advised that as Perennial supply of water is not obtainable. Author terminated if watershed development techniques are enforced, will lead to increase within the living standard and financial condition of individuals of Sangola town. Parag R. Thakare [5] et al. (2013) Aim of this project is to emphasize the importance of the water conservation to overcome from shortage of water. The activities undertaken during this project include soil and conservation measures like construction of Bandhara. Mrs.Vidula Arun Swami et al. [6] (2011) in this study Watershed Management, A Means of Sustainable Development a case study they shows that In this era of ever increasing water demands and rapidly depleting water resources coupled with Overpopulation, it has become necessary to develop the means to recharge the ground water resources which are necessary for future requirements. Pandurang D. Jankar et al.[7] (2013) A Case Study of Watershed Management for Madgyal Village, they shows that Geographic information system (GIS) an essential tool for watershed planning and management tasks. Priya Sangameswaran [8] (2006) This paper discusses the extent to which these changes have been equitable, with a particular focus on equity across different landholding categories. J. Nittin Johnson et al.[9] (2013) Study discuss Explosion in population, has light-emitting diode to extend in demand of varied natural resources, as well as that of the foremost precious resource-water, particularly for irrigation and agricultural functions.Vishal P. Kumbhar et al. [10] (2013) they have studied the effectiveness of watershed management through the case study, actual implementation of watershed management options such as farm pond, gully plugs, contour trenching it is found that there is water available for irrigation to after watershed management options.

V. N. Sharada et al. [11] (2005) Author concluded that frequency of disasters, such as landslides, floods, droughts, cyclones, hailstorms, siltation of reservoirs and deterioration of water bodies is increasing. Integrated watershed management in these regions requires adoption of innovative soil conservation and crop management techniques to prevent land degradation, maintain soil fertility and ensure environmental security for achieving sustainable productivity.

2. METHODOLOGY

2.1 Study Area & Data Collection

A. Village Introduction

Chincholi is a village situated in Jalgaon district in Maharashtra. Situated in rural region of Jalgaon district of Maharashtra. According to the administration records, the pincode of Chincholi is 425003. The village has 475 homes. It belongs in Nashik Division. It is located 10 km towards from District headquarters. The total geographical area of the village is 857.1 hectares. Chincholi has a total population of 5000 people. Latitude: 17.4561023N Longitude: 77.419273 E and Elevation: 462 m.

B. Basic Details of Chincholi Village

The total geographical area of Chincholi village, as per 2019 records, is approximately 857.51 hectares. A significant portion of this land, around 578 hectares, is utilized for agricultural activities, of which nearly 502 hectares are irrigated, while the remaining 76 hectares depend on rainfall, making them un-irrigated. The village also comprises about 232.5 hectares of non-agricultural land. In addition, nearly 10 hectares fall under the category of culturable waste land, and around 2 hectares are currently lying as fallow. Furthermore, another 4 hectares are also classified as current fallow lands. Among the irrigated areas, about 71 hectares benefit from canal water, and around 5 hectares are irrigated through tube wells. The village also contains 31 hectares of land designated as permanent pastures and grazing areas, supporting livestock and contributing to the local economy

C. Chincholi Village Rainfall Data [13]

YEAR	2014	2015	2016	2018	2019	2020	2021	2022	2023
Rainfall Data in (MM)	805.6	423.2	744	393.3	921.6	903.6	855.9	752.2	590.6

2.2 GIS Work Study

A. Preparation of Thematic Maps:

The base map and remote sensing data were utilized to generate various thematic map layers, including the drainage map, contour map, slope map, and a map indicating proposed water harvesting structures. The watershed boundary, contours, and drainage network were digitized on the base map to produce the contour and drainage maps. The satellite data (in digital format) were geo-referenced and rectified using the base map as a reference layer.

1) Digital Elevation Model (DEM):

A Digital Elevation Model (DEM) is a specialized digital dataset that represents the topographic relief of a land surface using points of known elevation. It provides a digital representation of ground surface elevation and is commonly used to model terrain. The term "DEM" is frequently applied to any digital representation of a topographic surface.

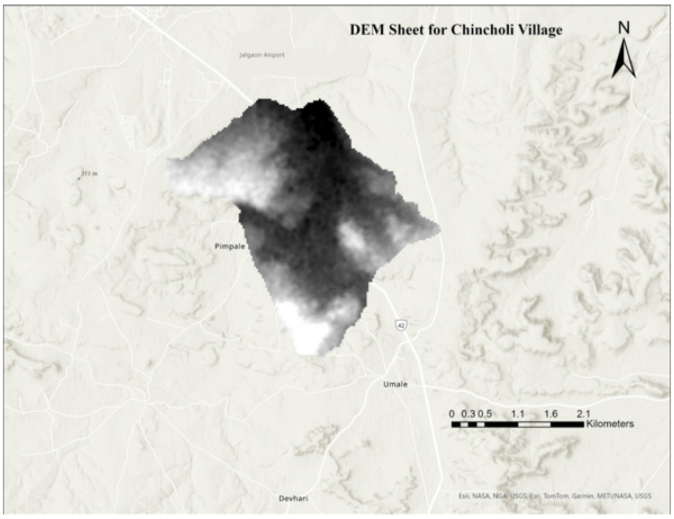

Fig No. 1: Digital Elevation Model (DEM) of Chincholi Village

2) Outline Map

Fig No. 2: Outline Map of Chincholi Village

3) Contour Map

The elevation contours suggest that water generally flows from the northwest and western parts of the watershed toward the southeast, aligning with the natural slope of the terrain. This drainage network provides critical insights for water resource planning, soil conservation, and the potential placement of water harvesting structures.

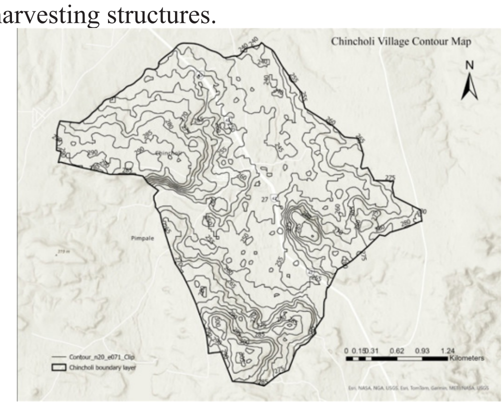

Fig. No. 3 Contour map of Chincholi village

4) Land Use Land Cover

The LULC map of Chincholi village, developed through satellite imagery classification in ArcGIS Pro, reveals distinct spatial patterns of land cover. Tree cover constitutes the predominant class, followed by grassland and cropland, reflecting the region's agrarian economy. Built-up areas (represented in red) are linearly concentrated along central transportation corridors, denoting settlement zones, while fragmented shrubland and bare/vegetation patches indicate transitional or degraded landscapes. Minor water bodies (depicted in blue) are sporadically distributed, likely supporting local irrigation and domestic needs. This analysis highlights the village's semi-rural development and ecological composition, providing a foundation for sustainable land-use planning, agricultural optimization, and conservation strategies.

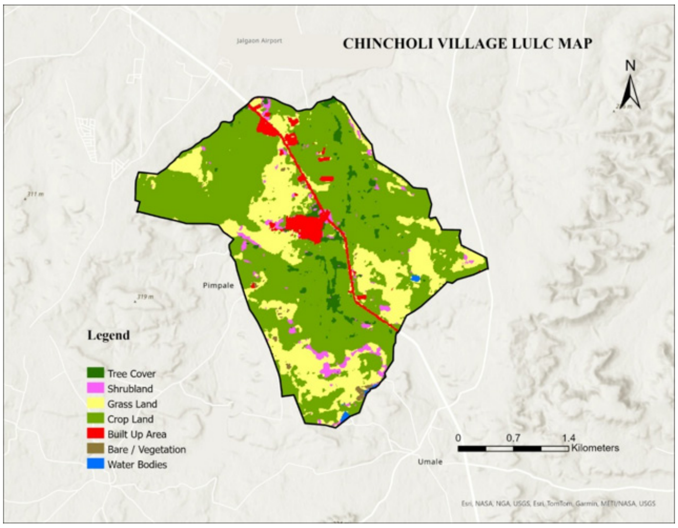

Fig No. 4: Land Use Land Cover Map of Chincholi Village

5) The Drainage Map of Chincholi Village

The drainage map of Chincholi village was generated using a Digital Elevation Model (DEM) in ArcGIS Pro, enabling accurate terrain analysis and manual delineation of the watershed's drainage network. The map reveals a dendritic to sub-dendritic pattern, indicative of natural flow over a homogeneous geological substrate. First-order streams converge into higher-order channels, forming a hierarchical network that ultimately drains southward into a major water body near Kandari. Stream orders, color-coded for clarity, adhere to Horton's laws, with stream frequency diminishing as order increases. This structured drainage system underscores the region's hydrological connectivity and provides a basis for watershed management and erosion control strategies.

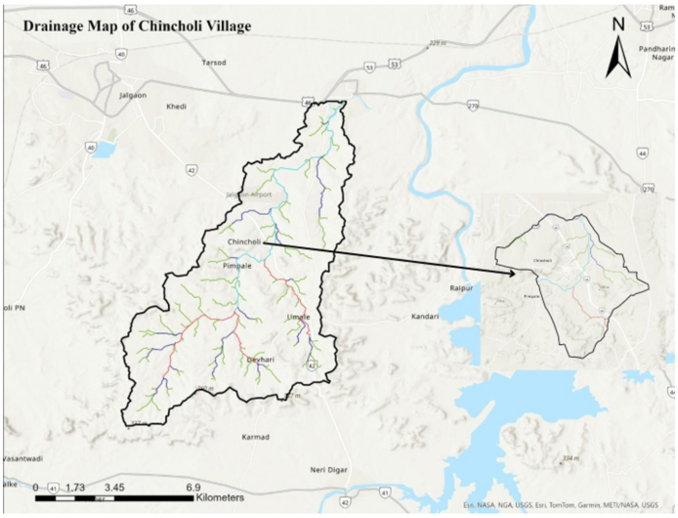

Fig No. 5: The Drainage Map of Chincholi Village

6) Groundwater Map

The groundwater level map of Jalgaon district classifies Chincholi village within the light pink zone (17.40-33.29 meters BGL), indicating critically low groundwater availability. These exceptional depths reflect significant aquifer stress, likely resulting from compounded factors including inadequate recharge, excessive extraction, and restricted aquifer permeability. The village's hydrological condition demands immediate implementation of integrated water conservation strategies, including: (1) structural interventions (check dams, recharge shafts); (2) large-scale rainwater harvesting systems; and (3) regulated extraction protocols coupled with community water budgeting. This critical situation designates Chincholi as a priority zone for artificial recharge initiatives within comprehensive watershed development programs, where sustainable management practices could potentially reverse current depletion trends.

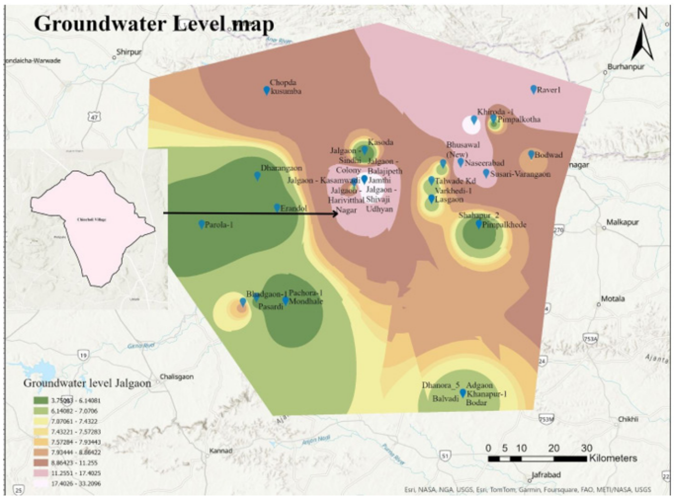

Fig No. 6: Groundwater Map of Chincholi Village

7) Soil Map

The soil map of Chincholi village, a subset of the broader Jalgaon region, was prepared to classify the local soil types using GIS techniques. According to the analysis, Chincholi is predominantly covered by Chromic Vertisols, a soil type known for its high clay content, swelling and shrinking behavior, and moderate to high fertility. These soils are typically dark-colored and are well-suited for cotton, soybean, and pulse cultivation, which aligns with the region's agricultural profile.

The mapping process incorporated soil data overlaid on spatial reference layers using ArcGIS. The inset highlights Chincholi's distinct position in the regional soil context and provides a focused view for village-level planning. Understanding the soil type is essential for determining appropriate cropping patterns, irrigation strategies, and soil conservation measures.

Chromic Vertisols, due to their shrink-swell properties, require careful water management. Hence, this soil analysis plays a crucial role in the design of water harvesting structures and sustainable agricultural development in the village.

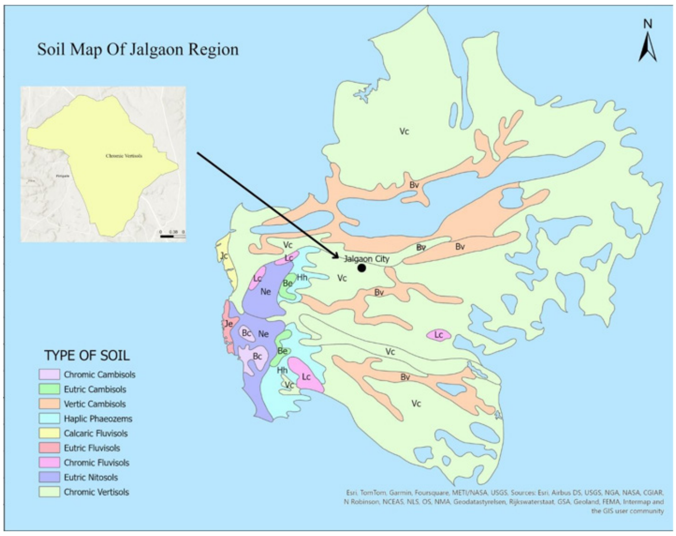

Fig No. 7: Soil Map of Jalgaon Region

3. RESULT AND DISCUSSION

3.1 Runoff calculations:

Average yearly rainfall in Chincholi village = 71cm.

1. Runoff by Inglis formula = [P * (P-17.78)] /254
   = 14.87 cm

2. Total available water = Area of watershed (Sq. m) x Rainfall
   = 857.71ha x 71cm
   = 6088321 cum

3. Ground water recharge = Area of watershed (Sq.m) x Avg. fluctuation x Specific yield
   = 8575100 x 15 x 0.02
   = 2572530 cum

4. Evapotranspiration = (40%) of Precipitation
   = 40/100 x 6088321
   = 2435328.4 cum

5. Runoff by using basic formula Runoff =Precipitation - Basin recharge
   = 6088321 – 2572530 = 3515791 cum

6. Water available for artificial recharge for watershed

development = Runoff – Evapo-transpiration
= 3515791 – 2435328.4
= 1080462.6 cum

3.2 Water requirement calculation:

1. Water requirement for domestic use water requirement per capita

= 60liter/day
= 5000 x 6 = 300000 litres.

Annual water requirement for domestic = 300000 x 365
= 109500000cum.

Crop Name	Area (ha)	Requirement Per ha (in TCM)	Total Water Demand (in TCM)
Cotton	70	0.60	42
Wheat	40	0.45	18
Sorghum	50	0.45	22.5
Soyaben	35	0.45	11.75
Tur	29	0.40	11.06
Groundnut	32	0.65	20.8
Other	11.49	0.65	7.468
	TOTAL AREA =267.49		=138.118

Water Requirement for Irrigation

2. Total water requirement

1. Domestic = 109500000

2. Irrigation = 138000

Total Water Requirement = 109638000 cum

Total Water Requirement for Chincholi Village is 109638000 cum.

A) Water to be stored in watershed:

Total availability of water for recharge is 168924.1 cum

Sr. No.	Type of structure	No. of structures	Water to be stored (cum)	Total water available (cum)
1	Rain water harvesting	475	17199.75	20620.7001 cum
2	Farm pond	3	3328.17	
3	Gabion structure	3	12.7801	
4	Trenches	40	80	

B) Proposed watershed management structure Estimation:

Sr. No.	Type of structure	No. of structures	Area of Structure	Cost of structure per unit	Total cost in Rupees
1.	Rain water harvesting	475	-	24,000/ m3	1,04,50,000 Rs./-
2.	Percolation Pond	3	9375	284/m3	26.62,500 Rs./-
3.	Trenches	-	308	284/m3	87,472 Rs./-
4.	Gabion structure	3	31	751.44/ m3	23,292.64 Rs./-
TOTAL					1,32,23,266 Rs./-

Total cost for constructing watershed management structures for Chincholi village is 1, 32, 23,266 rupees.

C) Locations for proposed watershed structure:

With the help of GIS data and GSDA guidelines following sites are suitable for watershed structures. It is very easier to locate locations for structures with the help of contour map, land use land pattern map and drainage map.

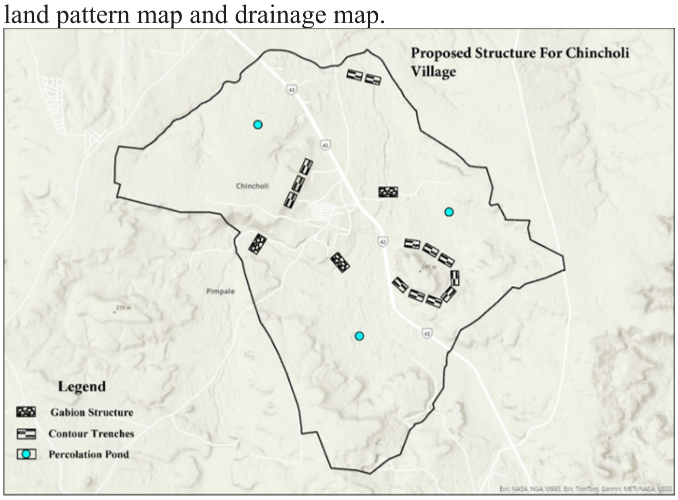

Fig No. 8: Locations for proposed watershed structure

4. CONCLUSION

In Chincholi village, there is water scarcity during months of February to May for drinking as well as for irrigation. Population of Chincholi village is increasing rapidly. The annual average rainfall is also not sufficient. Following are the concluding remarks given below:

1. Chincholi village will become self-dependent from water supply point of view if the proposed structures as mentioned below are implemented:
2. Total cost of rainwater harvesting structures is 1,04,50,00 rupees and it can be easily managing by individual basis by villagers. It will effectively solve problem of drinking water and domestic use. This will help to effective watershed management in the Chincholi village
3. Various watershed measures like Percolation pond, Contour Trenches and Gabion structure should be implemented to cope up with the drought conditions. With the help of GIS software location of watershed structures are easily located.
4. Maintenance programme for water storage structure should be done regularly like removing silt in the wells and it will result in increased water storage capacity of above structures and increase ground water table.
5. Growing of cash crops, use of drip irrigation, awareness camps regarding agriculture, irrigation as well as government schemes and subsidy schemes will benefit the farmers of Chincholi village.
6. Perennial source of water is not available to fulfill the requirement. If watershed development techniques are

implemented, it will result in increase in the living standard and economic condition of people of Chincholi village.

7. GIS is effective tool for watershed management.

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